Table 6-11. Recommended improvement actions for Admiralty Inlet

Improvement Action	Benefit to natal Chinook	Benefit to Other (non-natal) Chinook	Benefit to summer chum, bull trout, other fish
Restore drift cell functions in shoreline restoration targets 7,10,12 and 14 in Fig. E-5.5		Improved feeding function through forage fish production for all populations	Improved feeding function through forage fish production for all species

6.6 Whidbey Basin

1. Salmon Use

Chinook

This is part of the Whidbey Basin and Padilla and Samish bays region, which includes 10 of the 22 independent populations of Chinook within the Puget Sound ESU. Each of the independent populations in this region emanate from this sub-basin:

- Lower Skagit
- Upper Skagit
- Cascade
- North Fork Stillaguamish
- South Fork/Mainstem Stillaguamish
- Suiattle
- Lower Sauk
- Upper Sauk
- Skykomish
- Snoqualimie

a) Juvenile

- Juvenile Chinook salmon of all four life history types for all 10 natal populations utilize this sub-basin for feeding and growth, refuge, physiological transition and as a migratory corridor (juvenile salmon functions).
- Juvenile Chinook salmon from neighboring populations utilize this sub-basin for feeding and growth, refuge, physiological transition and as a migratory corridor.

b) Adult

- Sub-adult and adult salmon from Puget Sound populations utilize habitats within this sub-basin as a migratory corridor and grazing area.

Other Listed Species (not comprehensively reviewed or assessed for this sub-basin)

- Chum salmon: Natal populations of the Hood Canal/Eastern Strait of Juan de Fuca Summer Chum ESU do not exist in this sub-basin. Non-natal use may occur, but it is not known for certain.

- Bull trout (anadromous): The Puget Sound Management Unit contains four core areas in this sub-basin (Snohomish/Skykomish, Stillaguamish, Upper Skagit, Lower Skagit). With the exception of the Upper Skagit core area, each core area is critical for sustaining the distribution of the anadromous bull trout life history trait within Puget Sound. In particular, the Lower Skagit core area is absolutely essential for this management unit. Bull trout from other basins are confirmed to use the Snohomish River estuary (USFWS 2004). Finally, the four core areas contain an estimated 33 local populations, greater than 3500 adult fish (estimated) and population trends varying from unknown to stable to increasing (USFWS 2004).

2. Ecological and Landscape Conditions

Food Web, Ecological Conditions

Whidbey basin and its nearshore environment is a unique region of Puget Sound. The Skagit, Snohomish and Stillaguamish are the three largest rivers in Puget Sound and all empty in the Whidbey Basin (Figure E-5.1), generating a strong surface outflow from Possession Sound (Ebbesmeyer et al, 2002). Of these rivers, the Skagit River is the largest source of freshwater flowing into Puget Sound. The depth of the density gradient in Possession Sound is close to the surface and well stratified (Van Voorhis et al, 2002), indicative of the large volume of freshwater flow into Whidbey Basin. A reduction of freshwater flow can affect the stratification. Portions of Whidbey basin are susceptible to low levels of D.O. (due in part to slower circulation and nutrient input) and poor water quality (e.g., lower Stillaguamish – West Pass). During low freshwater flows the water can heat up and the D.O. can decrease. Nutrient limitation can be pronounced in Possession Sound, and Van Voorhis et al, (2002) reported a pattern of nutrient limitation near the end of summer snowmelt.

Landscape Conditions

Because of the extreme influence of freshwater, the entire Whidbey Basin behaves like a giant estuary with all shorelines being affected by river discharge and sedimentation. Because the Snohomish and Stillaguamish are much older river deltas than the Skagit, the extent of tidal influence can be measured far upstream from the delta face and many important estuarine habitats are within distributary sloughs of the river channel, not in a deltaic fan offshore in the bay. The effect of strong southerly winds from the central basin and restricted tidal connection through Deception Pass coupled with the potentially high nutrient loads from the rivers, the waters of Whidbey Basin can become eutrophic.

See Figures E-5.1 through 5.3, E-6.4 and 6.5 in Appendix E for additional information about landscape conditions.

Overall area

- Total area (deep-water plus nearshore) is 157,631 acres (246.3 square miles).
- Deep-water portion (marine waters landscape class) comprises 80,128 acres (125.2 square miles), or 51% of the total sub-basin area.

Nearshore area

- Nearshore portion comprises 77,440 acres (121.0 square miles), or 49% of the total sub-basin area. As part of the nearshore, the Skagit, Stillaguamish and Snohomish estuaries are natal estuaries (landscape class) for the independent Chinook populations listed above, comprising 74.25 square miles (61%) of the total nearshore area within this sub-basin.
- Nearshore area within this sub-basin is 19% of the nearshore area of the entire Puget Sound basin.
- Contains 352 miles of shoreline (beaches landscape class).
- The "key" bays (landscape class) identified in this sub-basin are Similk Bay, Dugula Bay, Crescent Harbor, Oak Harbor, Penn Cove, Holmes Harbor, Livingston Bay, Triangle Cove, and Tulalip Bay.
- Fifty-six linear miles (16%) of the shoreline is designated as marine riparian (defined as the estimated area of length overhanging the intertidal zone).
- In this sub-basin, 46% of the shoreline (162 linear miles) has eelgrass (*Zostera marina* and *Z. japonica*); may be patchy or continuous.
- In this sub-basin, 2% of the shoreline (6 linear miles) has floating kelp; may be patchy or continuous. Also in this sub-basin, 7% of the shoreline (24 linear miles) has non-floating kelp; may be patchy or continuous.

Pocket Estuary Analysis

We identified 17 pocket estuaries in this sub-basin: two in Skagit Bay, several scattered throughout Saratoga Passage, and several in Port Susan and Possession Sound.

- Freshwater sources were observed in nine of 17 pocket estuaries,
- Based on the assumptions listed in Appendix B, all three of the Chinook functions (feeding, osmoregulation and refuge) were estimated to occur in six of the 17 pocket estuaries,
- Two pocket estuaries were estimated to be *properly functioning*. Six pocket estuaries were estimated to be *not properly functioning*. The remaining pocket estuaries were recorded as *at risk*.

Drift Cell Analysis

The complexity of Whidbey Basin shoreforms is as a result of a complex interplay between river sediments and longshore drift processes that affect steep sandy bluffs. The stability of these bluffs compared to Admiralty Inlet means that landslides or other mass wasting effects may be more important to add sediment to beaches than wave generated bluff erosion. The drift cell

characterization for this sub-basin and is presented in Figure E-5.5 and subsequent text in Appendix E. Littoral drift, feeder sources, deltaic processes, deposition, and recommendations for protection and restoration are discussed in Appendix E and highlights of recommendations for protection and restoration are included in Tables 6-10 and 6-11.

Threats/stressors

Loss and/or simplification of delta and delta wetlands

Comparison of historical wetland area and wetland area reported in Bortleson et al. (1980) revealed that for the Skagit delta, the estimate area of subaerial wetlands decreased from historical to date of survey in 1980 from 6.18 to 4.63 square miles (decreased by 1.55 square miles). The estimated area of intertidal wetlands could not be calculated because historical estimates were not provided. In 1980, 21.24 square miles of intertidal wetlands were reported.

Comparison of historical wetland area and wetland area reported in Bortleson et al. (1980) revealed that for the Stillaguamish delta, the estimate area of subaerial wetlands increased from historical to date of survey in 1980 from 1.15 to 1.39 square miles (increased by 0.24 square miles). The estimated area of intertidal wetlands could not be calculated because historical estimates were not provided. In 1980, 7.72 square miles of intertidal wetlands were reported.

Comparison of historical wetland area and wetland area reported in Bortleson et al. (1980) revealed that for the Snohomish delta, the estimate area of subaerial wetlands decreased from historical to date of survey in 1980 from 15.06 to 3.86 square miles (decreased by 11.2 square miles). The estimated area of intertidal wetlands decreased from historical to date of survey in 1980 from 5.01 to 3.40 square miles (decreased by 1.61 square miles). The change in wetland habitat area between historical and current (1970's) condition in the Snohomish estuary is substantial. However, many of the agricultural lands made possible by historical diking are no longer actively worked. Thus, the Snohomish estuary offers significant opportunity for restoration.

Delta building (progradation) has occurred in the Stillaguamish River due to its quiet receiving waters, whereas in the Skagit and Snohomish delta, delta building has been less so because of the marine water's ability to move sediment from the delta front (Bortleson et al, 1980).

Historically, estuarine wetlands were extensive in the Skagit-Samish delta, consuming an area more than twice that of the Nooksack, Stillaguamish and Snohomish deltas, combined (Collins et al, 2003). Diking and draining of wetlands has reduced the area. The most extensive changes have occurred in the valley wetlands and loss of valley floor forests where most of the dense river bottom forests in Puget Sound have been eradicated (Collins et al, 2003). In a reconstruction analysis, Collins et al, (2003) showed the Stillaguamish River system was once similar to the Nisqually River (anastomosing pattern). Prior to extensive modification of the landscape by settlers, large floodplain wetlands and extensive estuarine marshes "accounted for nearly two-thirds (62%) of the valley bottom" of the Snohomish River (Collins et al, 2003). The removal of instream LWD has also impacted the Skagit, Snohomish and Stillaguamish river systems (Collins et al, 2003). The lower Snohomish and Stillaguamish River systems have been

dramatically altered. In the Skagit River alone, between 1898 and 1908, 30,000 snags were removed (Collins et al, 2003).

Alteration of flows through major rivers

Three dams are located on the upper Skagit River, and are believed to be located in an area of a historical migration barrier (USFWS 2004). The flow regime downstream of Skagit River must adhere to Skagit Hydroelectric Project Fisheries Settlement Agreement (USFWS 2004). The three dams in the upper Skagit system have altered the transport of LWD to the lower river and Skagit estuary, resulting in reduced habitat complexity as compared to historical conditions (USFWS 2004).

Modification of shorelines by armoring, overwater structures and loss of riparian vegetation/LWD

The projected population growth in Skagit and Snohomish counties between 2000-2025 is 60% (61, 818 people) and 53% (323,290 people), respectively (PSAT 2004). In this sub-basin, shoreline armoring occurs along nearly 152 miles (44%) of the shoreline. One hundred forty four miles of shoreline are classified as 100% armored. Over 190 miles are classified as 0% armored. The total number of overwater structures is 5,046, consisting of ramps (169), piers and docks (369), small slips (4,390) and large slips (118). Overwater structure are observed intermittently throughout the sub-basin, and are concentrated in the Snohomish estuary (Everett region), and the LaConnor region. Within 300 feet of shore railroad grades occur along 3.8 miles, following the eastern shoreline from Mukilteo north to Everett. See the loss and/or simplification of deltas and delta wetlands piece (above) for a discussion on the loss of LWD.

Contamination of nearshore and marine resources

Regions with 15% or greater impervious surface area are concentrated in the Marysville and Everett area, as well as Oak Harbor (PSAT 2004). In this sub-basin, Everett Harbor is one point source for contaminants such as from sewage and toxic contaminants (Washington Sea Grant, 2000). Potential non-point sources of contamination include stormwater runoff and failing septic systems (Washington Sea Grant, 2000). Surveys in 1996-1997 show depressed dissolved oxygen concentrations in Penn Cove (Washington Sea Grant, 2000), a region especially susceptible and sensitive to eutrophication (PSWQAT 2002a). The Skagit and Snohomish Rivers, comprising 47% of the Puget Sound Basin, contribute 50% of the nutrient loads (Embrey and Inkpen 1998). See the discussion in Ecological Conditions for more on water quality and dissolved oxygen.

Whidbey Basin is second only to central Sound in the degree of degraded sediments (PSAT 2002a). Chemical concentrations in Puget Sound sediments are typically greater in urban/industrialized regions, such as in Everett Harbor (PSAT 2002a). Nine percent of the area of this sub-basin exceeds the state's sediment quality standards and the cleanup screening levels.

Figure E-5.3 presents the distribution of water quality impairments across the sub-basin.

Alteration of biological populations and communities

The number of hatcheries operating in this sub-basin is 10. Specific hatchery reform recommendations for this region have been formulated by the Hatchery Scientific Review Group available at the following websites.
http://www.lltk.org/pdf/HSRG_Recommendations_February_2002.pdf
http://www.lltk.org/pdf/HSRG_Recommendations_March_2003.pdf

Shellfish aquaculture is not practiced in this sub-basin to any significant degree because of proximity to urban centers and potential bacterial contamination. A small shellfish aquaculture operation occurs within Triangle Cove.

Transformation of land cover and hydrologic function of small marine discharges via urbanization

Warm Beach and Tulalip Bay are considered at risk for salmon functions largely due to impacts of urbanization. See Figure E-6.4 for a list of pocket estuaries and stressors noted in a review of oblique aerial photos.

Transformation of habitat types and features via colonization by invasive plants

Nine percent of the shoreline (33 miles) in this basin contains patchy or continuous *Spartina spp.*. Also, 4% of the shoreline (13 miles) contains *Sargassum muticum*, which may be patchy or continuous.

B. Evaluation

In this section we list goals and evaluate the level of realized function for natal and non-natal Chinook, summer chum, and bull trout. From this we then list each of the proposed protection and restoration actions for this sub-basin, and describe the benefits to natal Chinook, non-natal Chinook, and summer chum and bull trout (if any).

Goals for listed salmon and bull trout whose natal streams are in this sub-basin

a) Provide early marine support for all four life history types (fry migrants, delta fry, parr migrants, yearlings) for the 10 independent populations of Chinook salmon emanating from this sub-basin,
b) Provide support for sub-adult and adult Chinook salmon populations who utilize habitats within this sub-basin as a migratory corridor and grazing area.
c) Provide marine support for sub-adult and adult anadromous bull trout populations (approximately 33) within the four core areas in this sub-basin (Snohomish/Skykomish, Stillaguamish, Upper Skagit, Lower Skagit). The Lower Skagit core area is absolutely essential to sustaining the distribution of the anadromous bull trout life history trait within Puget Sound.
d) Provide for connectivity of habitats; also, adequate prey resources, marine foraging areas, and migratory corridors for juvenile, sub-adult and adult Chinook, and bull trout.

e) Provide early marine support for independent spawning aggregations occurring in this sub-basin.

Goals for listed salmon and bull trout whose natal streams are outside this sub-basin

a) Provide support for all neighboring Puget Sound populations (juveniles, sub-adults, and adults) that utilize nearshore and marine regions of this sub-basin as a migratory corridor.

Realized function for listed salmon and bull trout

Fry migrant Chinook – Fry migrants from each of the major rivers will be well supported by the abundance of low wave energy shorelines in this sub-basin, however, few pocket estuaries are currently available and most are in poor condition for supporting fry migrants (Figure E-5.2). This is more likely to affect this life history type during storm events. The frequent seasonal flooding of these systems is likely to disburse fry migrants widely throughout the sub-basin so it is expected that even pocket estuaries at some distance from the delta may serve natal functions during these events. Small streams embedded in shorelines may function as pocket estuaries. Any increase in armoring of residential shorelines is of concern for support of fry migrants. See Figure E-6.4 for a list of pocket estuaries and observed stressors. In addition, fry migrants may be impacted by the concentration of overwater structures in the Snohomish estuary and the LaConnor region.

Delta fry Chinook – The three large natal deltas within this sub-basin have the potential to produce large numbers of delta fry. The Snohomish delta has large amounts of potential habitat to support this life history type upstream of Everett because the tidal influence continues several miles inland. However, much of that potential habitat is locked up behind older industrial and agricultural infrastructure as well as ongoing uses. Considerable ongoing restoration within this delta is expected to greatly improve the support for delta fry. Delta fry in the Snohomish estuary, however, will be more exposed to poor water quality conditions in Everett Harbor due to contaminant loadings from toxics and sewage discharges (Figure E-5.3) than delta fry from the other two estuaries. Contaminated sediments and impaired invertebrate communities in Everett Harbor will likely impact this life history type. The Stillaguamish and Skagit deltas are greatly reduced in size compared to their historic condition, largely from agricultural diking. Delta fry support is likely to be a mere fraction of the historic condition. Only limited tidal restoration has occurred in these deltas and much more will be needed to significantly boost this important life history type.

Parr migrant Chinook – Parr migrants will be well supported by the large numbers of smaller life history types and forage fish within the sub-basin as a food source. Parr migrants from main basin populations also use the protected shorelines of this sub-basin for support. The density of fish in this sub-basin from these three deltas and neighboring sub-basins may suggest that competition is a factor in supporting this life history type.

In addition, poor water quality and contamination will likely impact this life history type. Low dissolved oxygen in the lower Stillaguamish, Penn Cove, and Possession Sound may pose a problem for this life history type as the fish are migrating throughout the sub-basin searching for

forage. Contaminated sediments and impaired invertebrate communities in Everett Harbor may also impact this life history type.

Yearling Chinook – An abundance of forage fish and smaller life history types are available as a food source within this sub-basin so yearlings should be well supported. However, poor water quality and contamination may impact this life history type. Low dissolved oxygen in the lower Stillaguamish, Penn Cove, and Possession Sound may pose a problem for this life history type as the fish are migrating throughout the sub-basin searching for forage. Contaminated sediments and impaired invertebrate communities in Everett Harbor may impact this life history type.

Sub-adult and adult Chinook – We hypothesize the survival of sub-adult and adult Chinook salmon is likely dependent on several factors: the production and availability of forage fish species within nearshore regions, adequate water quality, low contamination levels and a healthy food chain, and the presence of marine vegetation, among others. Low dissolved oxygen levels and a reduction in prey, as well as contaminated food sources in the regions mentioned above have the potential to impact outmigrating sub-adults and returning adults.

Listed summer chum – We hypothesize that Hood Canal/Eastern Strait of Juan de Fuca summer chum salmon do not use this sub-basin.

Anadromous bull trout – The Snohomish/Skykomish, Stillaguamish, and Lower Skagit core areas are critical for sustaining the distribution of the anadromous bull trout life history trait within Puget Sound (USFWS 2004). The Whidbey Basin's estuaries and nearshore waters provides critical foraging, migration, and overwintering habitats for sub-adult and adult anadromous bull trout. As in other sub-basins containing populations of anadromous bull trout, fish in this sub-basin feed on many prey items in productive shallow waters (USFWS 2004). As with yearling Chinook, and sub-adult and adult Chinook, bull trout may be impacted by poor water quality in estuarine and nearshore regions (e.g., Snohomish River, Penn Cove, Possession Sound), as well as contamination of sediments and prey items. Also, the loss of LWD in lower reaches of large rivers (e.g., Skagit), and estuaries, has reduced habitat complexity and can potentially impact bull trout.

All life history types in this sub-basin may be at risk from low dissolved oxygen from sewage discharges and poor oceanographic flushing.

This sub-basin is key to the viability of Chinook salmon and anadromous life forms of bull trout.

Table 6-12. Recommended protection actions for Whidbey Basin

Protection Action	Benefit to Natal Chinook	Benefit to Other (non-natal) Chinook	Benefit to summer chum, bull trout, other fish
Protect all deltas, shorelines and pocket estuaries within the entire basin from further degradation, particularly all three natal deltas, Similik and Tosi Point pocket	Sustained early marine support of all 4 life history types of Skagit, Stillaguamish and Snohomish populations (feeding	Sustained support for neighboring Puget Sound populations (e.g., Lake Washington and Duwamish Chinook, larger	Sustained support for anadromous bull trout and other species. Functions addressed: feeding and growth, refuge,

estuaries and shoreline protection targets 3,5,6, 9-12 and 16 in Fig. E-6.5)	and growth, refuge, osmoregulatory, migration functions). Addresses all four VSP parameters	juveniles from other populations). Functions addressed: feeding and growth, refuge, osmoregulatory, migration	osmoregulatory, migration
Protect water quality within the sub-basin. There is the potential for dissolved oxygen problems/eutrophication due to excessive nutrient input (sewage outfalls, spills, agricultural). Prevent further degradation of D.O. and other water quality factors including avoidance of further stormwater loadings and NPDES discharge loadings	Sustained growth of all 4 life history types of Skagit, Stillaguamish and Snohomish populations.	Sustained migration functions for Lake Washington and Duwamish and other populations	Sustained growth of anadromous bull trout and other species.
Protect against catastrophic events	Sustained feeding, growth, osmoregulation, refuge and migration functions for all 3 natal populations	Sustained migration functions for all populations	Sustained migration functions for other species; feeding, growth, osmoregulation and refuge for anadromous bull trout
Ensure the amount of fresh water flowing into this sub-basin remains constant and does not drop to lower levels through added diversions, withdrawals, etc. A loss of freshwater may precipitate eutrophication and low DO in Possession Sound	Sustained growth of all 4 life history types of Skagit, Stillaguamish and Snohomish populations.	Sustained migration functions for Lake Washington and Duwamish and other populations	Sustained growth of anadromous bull trout and other species.

Table 6-13. Recommended improvement actions for Whidbey Basin

Improvement Action	**Benefit to natal Chinook**	**Benefit to Other (non-natal) Chinook**	**Benefit to summer chum, bull trout, other fish**
Consider wastewater reclamation and reuse retrofits for all sewage discharge facilities within the sub-basin. Redirection of sewage treatment discharges to upland treatment and reuse/recharge systems will help to reduce summer time loadings that are degrading D.O. levels and shifting nearshore community structure.	Improved feeding, growth, and migration functions for all three natal populations	Improved feeding and migration functions for other populations	Improved feeding, growth and migration functions for anadromous bull trout and other fish species

Improvement Action	Benefit to natal Chinook	Benefit to Other (non-natal) Chinook	Benefit to summer chum, bull trout, other fish
Restore all three major deltas by removing agricultural levees and navigational structures that impede natural sediment and tidal processes in shoreline target areas 1,2,4 and 15 in Fig. E-6.5	Improved feeding, growth, refuge, osmoregulation and migration of all 4 life history types of all three natal populations	Improved feeding, growth, refuge and migration of other populations, especially Lake Washington and Duwamish	Improved feeding, growth, refuge, osmoregulation and migration of anadromous bull trout and other fish species
Restore all at risk pocket estuaries within the sub-basin, which includes Elger Bay, Triangle Cove, Livingston, Warm Beach, Tulalip Bay, Honeymoon Bay, Race Lagoon and Penn Cove	Improved feeding, growth, refuge, osmoregulation and migration of all 4 life history types of all three natal populations	Improved feeding, growth, refuge and migration of other populations, especially Lake Washington and Duwamish	Improved feeding, growth, refuge, osmoregulation and migration of anadromous bull trout and other fish species
Restore all shoreline restoration targets within the sub-basin (areas 7,8,13 and 14 in Fig. E-6.5)	Improved feeding and migration functions for all 3 natal populations	Improved feeding and migration for other populations	Improved feeding and migration for anadromous bull trout and other fish species
Re-create hydrologic connections of Skagit Bay to both Padilla Bay and Stillaguamish delta to restore access to South Georgia Straits/Padilla Bay/Whidbey sub-basins corridor for Chinook migrants from all populations originating in the Whidbey Basin and South Georgia Straits sub-basins	Improved migration functions for Snohomish, Stillaguamish and Skagit populations (addresses spatial structure and diversity VSP)	Improved migration for Duwamish, Lake Washington and Nooksack populations. (addresses spatial structure and diversity VSP)	Improved migration functions for anadromous bull trout and other fish species (addresses spatial structure and diversity VSP)
Conduct a prioritized cleanup of contaminated sediment hot spots and ongoing toxic discharges in the Everett Harbor area	Improve connectivity between the Snohomish delta and other landscape classes for sensitive life history types such as fry migrants		Improve connectivity between the Snohomish delta and other landscape classes for anadromous bull trout and other fish species

6.7 Hood Canal

1. Salmon Use

Chinook

This subbasin comprises the Hood Canal region, which includes two independent populations of Chinook:

- Skokomish
- Mid-Hood Canal